EFFECTS OF FIRM-SPECIFIC FACTORS ON R&D EXPENDITURES OF AGRIBUSINESS COMPANIES

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Maud Roucan-Kane*, David Ubilava*, Pei Xu*
Dept. of Agricultural Economics, Purdue University
West Lafayette, Indiana 47907-2056
mroucan@purdue.edu, dubilava@purdue.edu, xup@purdue.edu
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Abstract

The objective of this paper is to determine how the firm's infrastructure, the financial characteristics of a company (net income, sales), and the organizational structure (number of acquisitions, age of establishment of the firm) affect R&D investments in the agricultural sector. We use data for companies under the SIC codes for agricultural chemicals, and crop planning and protection. The results based on analysis of 69 observations of 12 firms revealed that firm's financial and organizational infrastructure does affect its R&D expenditures. Older and larger firms tend to spend more on R&D. During the last 17 years the R&D expenditures with respect to the sales of the company have been reduced. Finally, contrary to the expectations, previous year's profit margins are negatively correlated with the R&D over the sales ratio of the following year.

Keywords: R&D, agriculture, chemicals, crop planning, crop protection, agribusiness, expenditures

JEL Codes: A10, O32, Q16

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Introduction

Innovation is one of the important factors for companies to stay in business and eventually grow. Moreover, quite often, innovation turns out to be the main reason for obtaining positive economic profits. Based on this, the closer the market is to perfect competition the higher should be the incentives for innovation (otherwise firms will generate zero economic profits). Number of theoretical and empirical studies (some of which are highlighted in the literature review) have justified the abovementioned statement.

However, increased market concentration (relaxing perfect competition assumptions) does not necessarily result in reduced incentives for innovation. The theoretical explanation is that more concentrated industry means larger market shares for the principal sellers, and hence, larger savings from process innovations (Scherer, 2001) or sales from innovative products. And so, as a result, the incentives for innovations are increased.

Innovation is hard to measure and to get data on. Number of patents can be considered as an output measure and often, Research and Development (R&D) is used as a proxy for input in innovation. Companies in agribusiness are no exception in terms of innovativeness. Among numerous agricultural industries, the chemical industry is one of the ones with significant share of R&D in the cost structure of the companies. Given the characteristics of the industry, it is characterized with certain level of concentration. Together with industry concentration there are number of firm-specific factors that also affect the innovativeness of the company and industry as a whole.

The objective of this paper is to determine how the firm's infrastructure (age), the financial characteristics of a company (net income, sales), and the organizational structure (number of acquisitions) affect R&D investments in the agricultural sector.

This research has several features that differentiate it from the previous studies. First, this research focuses solely on agribusiness industry. Second, unlike most of the previous studies we do not include industry-specific information (such as market share, concentration ratio, etc.) and mainly try to explain the reasons of change in R&D expenditures through firm-specific factors only. Third, we include previous year's net income as an explanatory variable, which will reveal the effect of firm's performance in one period on its R&D expenditures in the following period. Finally, we estimate and compare results from an OLS regression with variables in absolute terms and an OLS regression with variables in relative terms. The former regression allows us to determine the effect of the previous year's net income value on current year's R&D expenditures in absolute terms (when size effect is not eliminated); the latter regression allows us to observe the previous year's net income effect on current year's R&D expenditures in relative terms, that is when the size factor is taken into the account.

The rest of this paper is organized the following way. The first section of the paper presents the literature review and shows how most studies have focused on several industries usually non-agriculture related while our study focuses only on agricultural industries. The dataset used is then presented, followed by the model and some general descriptive statistics. We conclude with the presentation of the results, the limits and a discussion.

Literature Review

Ho, Tjahjapranata, Yap (2006) examined the effectiveness of R&D investment by measuring firms' growth opportunities. To do this, they examined the interaction effects of firm characteristics (firm size and financial leverage) and an industry characteristic (industry concentration), on the amount of R&D investment on firms' growth opportunities. Twenty two industries from COMPUSTAT dataset were examined for the period 1979-1998. They found a positive effect of R&D investment on firms' growth opportunities. This effect is amplified by large firm size while decreased by high industry concentration. Financial leverage is negatively related to growth opportunities. Industry concentration did not appear to be of importance. The author explain that the positive impact of market power arising from firm size may be offset by the negative effect of the propensity to fund negative NPV projects in a high-concentration market.

Acs and Audretsch (1988) presented a model which suggests that industrial innovative output is influenced by R&D and market structure characteristics (concentration). To measure innovative activity, the number of innovations was used with data collected from the U.S. small business administration system. Data was analysed by using simple regression analysis and the results showed that the number of innovations increases with increased industry R&D expenditures but at a decreasing rate. Industry innovation tended to decrease as the level of concentration rises. In addition, the paper found that unionization is negatively related to innovation activities. In terms of firm size effect, the paper concluded that the innovation activity of small firms is high relative to the industry level in industries in which skilled labour plays an important role.

Schimmelpfennig, Pray and Brennan (2004) looked at the effect of how concentration affects the amount spent on biotechnology R&D in the corn, cotton, and soybean seed industry. They estimated an independent linear simultaneous system (a research profit function model) for each of the three crops. The static mathematical modelling explicitly tested a Schumpeterian hypotheses in which market structure and R&D are jointly and endogenously determined. Four important factors of influence were controlled by the model: research intensity, technological opportunity, appropriability, and concentration. Appropriability refers to a firm's ability to profit from a given R&D investment. They found that concentration is negatively related to R&D intensity (which confirms Schumpeter's idea). Patents and industry concentration were found to be complements for corn and cotton, and substitutes for soybean. Public R&D had a small positive significant impact on all three crops. The results suggested that competition in biotech innovation markets appears to be important since reduced competition is associated with reduced R&D. Appropriability was found to be a complement to concentration for corn and cotton, but a substitute for soybean and for the entire sample.

Levin et al. (1985) argued that firms in concentrated markets can more easily appropriate the returns from their R&D investments. The data used for this study consists of survey observations, data from the Line of Business, and from the Census of Manufacturers for many industries. The study set up a structural model using 2SLS regression to study the effect of concentration on innovation while controlling for appropriability and technological opportunity available in each industry. Three dimensions of technological opportunity are used: closeness of science, external sources of technical knowledge, and industry maturity. Closeness of science refers to the relevance of various basic and applied sciences to the technology of each industry. Four external sources of technical knowledge, substituting for an industry's R&D effort, were examined including upstream suppliers of raw materials and equipment; downstream users of the industry's products, and government agencies and research laboratories. The results showed that R&D investments appeared larger in industries where a strong science base is present and where there are substantial government contributions to technical knowledge. The findings also proved that concentration promotes innovative effort and innovative output. This is consistent with what Schumpeter emphasized: concentration reduces market uncertainty and provides the cash flow required to conduct costly and risky R&D on an effective scale.

Two papers examined the relationship among advertising, market concentration and firms' R&D investment. Lunn (1989) estimated a simultaneous three equations model. The first equation regressed R&D on CR4 (4 firm concentration ratio), advertising to sales ratio, cash (operating income plus depreciation), ratio of total assets to total sales (proxy for capital intensity), industry value of shipments, growth in total sales, number of patents in the industry for process innovation, and a dummy for whether or not the industry is technically progressive. The second equation regressed CR4 on R&D expenditures, a proxy for minimum efficient scale, growth in sales, and number of patents in the industry for process innovation. Finally, the third equations regressed the advertising to sales ratio on R&D expenditures, concentration, cash, a dummy for whether or not the industry is a consumer good industry, and number of patents in the industry for process innovation. He found that market concentration encourages research activity, and advertising and research activity are seen as substitute.

Chauvin and Hirschey (1993) investigated whether investors recognize the long-term characteristics of advertising and R&D expenditures. The study exposed that advertising effect and R&D effect differ according to firm size. These two effects were moderately reduced for smaller firms reflecting that such efforts are often the focus of rivalry and imitation by bigger and better-financed rivals. In addition, the study found that R&D intensity has highly positive market value effects for all high-tech industries and high-tech firms.

Wahlroos, BackStrorn and Helsinki (1982) presented a simultaneous equation model of industrial structure and research and examined two types of barriers to entry: those following product differentiation and those from economies of scale. The model is estimated from Finnish cross-sectional data which includes 87 industries. Data were examined using both a standard 2SLS-procedure and a procedure allowing for dichotomous endogenous variables. The authors found that R&D activity is clearly more intense where markets are concentrated and products are differentiated. In addition, this R&D activity, far from destroying the foundations of market power, seemed to enhance it.

Hughes (1988) focused on the structure of industrial research and developments activity in the United Kingdom (UK) – in particular, its concentration and diversification. The author discussed that there were two main hypotheses about R&D and sales diversification in the industrial organization literature. One suggested that R&D may lead to sales diversification through unexpected inventions arising out of the R&D. The other suggested that diversification may result in a higher level of R&D since a diversified firm was more likely to have a use for R&D output so the risk of R&D was reduced. The paper looked at 100 large UK firms from non-ag industries. The author pointed out that the largest R&D – spending firms tend to be diversified with technological relatedness.

Conlin and Kadiyali (2006) conducted an empirical test to examine whether capacity was used to deter entry and whether the amount of investment in entry-deterring capacity was related to market concentration and market presence. The Texas lodging industry was used for the exercise to explore the relationship between idle capacity and market concentration. The regression results showed that higher level of concentration have greater idle capacity. Larger firms with higher incentive to deter entry have more idle capacity than those with smaller market shares.

Data

We used the Mergent online database available through the Purdue University libraries and looked for companies whose primary Standard Industrial Classification (SIC) Code is 2879[1] which stands for agricultural chemicals, nec (Not Elsewhere Classified). The data was compiled in April 2007. We found 60 companies (see table 1) and reported their financial information for (at most) the last seven reported years[2]. Our model imposes some restrictions on the data collection in the sense that the companies we include need to report their research and development expenses and need to report some of the following financial figures: marketing expenses[3], net sales/net revenue, net income[4], total assets, total liabilities, and stockholder's equity. For these reasons, only 16 out of the 60 companies could be used (see table 1). Most of the ones that were not included were non U.S. companies. Since we had such a small number of companies we decided to add companies whose primary SIC code is 0721[5] (crop planning and protection) which is the case for Syngenta. Mergent reported nine companies of which four could be used (see table 1). Finally, we wanted to include the big companies such as Monsanto, Bayer, BASF and etc. Therefore, we performed a search in the database Business and Company Resource Center under the SIC code 2870 (agricultural chemicals), which did not give any results in Mergent, and found the following companies listed: Syngenta and Bayer, followed by DuPont, Dow, BASF, Agrium, Monsanto, and Novartis AG. Therefore we gathered the financial information in Mergent for these companies as well. The complete list of companies used is available in table 2. All the financial information was captured through Mergent in thousands of dollars.

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[1] "This category includes establishments primarily engaged in the formulation and preparation of ready-to-use agricultural and household pesticides from technical chemicals or concentrates, and the production of concentrates that require further processing before use as agricultural pesticides. This industry also includes establishments primarily engaged in manufacturing or formulating agricultural chemicals, not elsewhere classified, such as minor or trace elements and soil conditioners. Establishments primarily engaged in manufacturing basic or technical agricultural pest control chemicals are classified in industries that manufacture industrial organic or inorganic chemicals" (Answers.com).

[2] The seven years are not the same for all companies for several reasons. First, at the time the data was gathered, the financial information for 2006 was not available for some companies and therefore 2005 was the last reported year. Second, some companies have merged, be bought before 2006 and therefore stopped reporting data at the time of the merger, buyout, or bankruptcy. In the entire sample, the earliest reported year is 1991 and the last reported year is 2006. Finally, for some companies, the information was available for less than seven years.

[3] For marketing expenses, we used the figure reported for "marketing & distribution", "sales and marketing expenses" or "selling and marketing".

[4] For some companies, net income was not available. Instead the calculation of profit before taxes minus taxes was used.

[5] « This group covers establishments primarily engaged in performing crop planting, cultivating, and protecting services." (Answers.com).

In addition to the financial information, we gathered information on the structure of the firm by using the History, Joint Venture, and Subsidiary sections of the Mergent database. This information was available for most companies. Using the history section, we counted the number of acquisitions and divestitures that each company was involved in for each year of interest. Was considered acquisitions, the purchase of some shares, the acquisition of additional shares, the complete purchase of a company, and the establishment of a new company/business. Was considered divestitures, spun-offs, companies/departments/businesses that were in part or completed divested, or disposed off. Using the Joint Venture and Subsidiary sections, we counted the number of joint ventures and subsidiaries each firm had. The joint venture and subsidiary information was not available by year but was just available for the last year of reporting and was therefore included that way in our dataset.

Model

The relationship between selected firm-specific factors and R&D expenditures is derived implementing the OLS (Ordinary Least Squares) regression. We estimate two linear regressions, where in the first case real figures of R&D expenditures and Net Income are presented and in the second case relative values with respect to sales are used. The first case is the type of approach that is commonly used by most of the researchers in analogous studies (e.g. Ho, Tjahjapranata, Yap, 2006). Usually they use logarithmic forms of explained and explanatory variables, where the coefficients can then be interpreted in percentage terms. However, since we decided to include net income variable in the regression, in certain occasions (when net income is not strictly positive), the logarithmic form is not applicable. So unlike most of the literature discussed above, our model will be interpreted in absolute instead of logarithmic terms As mentioned earlier, in this model we use variables in real instead of nominal dollars, which is consistent with previous literature but may bias the results. To correct this limitation, at least partially, we introduce a trend variable in this model, which will account for changes in R&D expenditures holding other explanatory variables constant.

As for the second model, we do not face a similar problem, since numbers are given in relative terms and so units are not in dollars any more. The discussed linear regression models are as follows:

$$R\&D = \beta_0 + \beta_1 NI(t-1) + \beta_2 ACQ + \beta_3 LARGE + \beta_4 NEW + \beta_5 TREND + \varepsilon \qquad (1)$$

$$R\&D/SALES = \beta_0 + \beta_1 NI(t-1)/SALES(t-1) + \beta_2 ACQ + \beta_3 NEW + \beta_4 TREND + \varepsilon \qquad (2)$$

where

R&D	annual R&D expenditures
NI(t-1)	previous year's Net Income
R&D/SALES	ratio of annual R&D expenditures and annual Sales
NI(t-1)/SALES(t-1)	ratio of previous year's Net Income and previous years annual Sales
ACQ	number of acquisitions made during the year
NEW	binary variable – 1 if firm was established after 1990
LARGE	binary variable – 1 if firm is large[6]

[6] We define as large companies those, whose natural log of sales exceeds 10, in absolute terms those will be the companies with annual sales roughly above $22 million. This value is taken arbitrarily, though it is close to the median of the observations. Each firms is qualified either as a large or small firm, that is, there is no case where

TREND	trend variable that will account for slope of change of the dependent variable over the time given that other explanatory variables are held constant

Large firms sometimes are described as not being as innovative but as having enough funds to buy innovative small firms that don't have the supply chain, the brand name to carry out the marketing of their product. In other words, "large firms may be less productive in undertaking R&D at the margin, [but] they are more effective in appropriating the results of the R&D output" Ho, Tjahjapranata, Yap (2006).

Instead of including year dummy variables (as for example Ho, Tjahjapranata and Yap, 2006 did) we included a time trend variable. This will allow us to account for possible R&D expenditures change trend over the estimated time period while having enough degrees of freedom.

Descriptive Statistics and Expectations

After cleaning the data (getting rid of observations with missing variables or outliers) and adjusting to the desired model we end up with 69 observations on 12 different firms (see Table 2).

The descriptive analysis shows that mean value of Sales of the observed firms is over 15 billion dollars, and the standard deviation is over 16 billion. R&D expenses are over one billion dollars, with a standard deviation as large as 1.3 billion. The average value of total assets is about 20 billion dollars with approximately the same value for the standard deviation. On average there are over 1.8 acquisitions in each firm happening during the year. 44% of total observed firms started operating after 1990. See Table 3 for the detailed statistics.

We expect that number of acquisitions and R&D expenditures are negatively correlated with each other based on previous literature. We also expect previous year's net income to have positive effect on current year's R&D expenditures. Finally, we expect that the newer firms must be spending more on R&D than older firms, since we assume that they are more "aggressive" in terms of obtaining market share.

Results

The results of the linear regressions of observed data are provided in Tables 4 and 5. The R software was used for obtaining estimates and other parameters of interest.

There are several interesting results obtained from these two regressions. According to the first regression, one dollar increase in previous year's net income value increases current year's R&D expenditures by 34 cents. Larger firms spend approximately one billion dollars more compared to smaller firms. Those firms that were established before 1990 tend to spend about

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some of the firm's observations fall into the large category and other observations of the same firm fall into the small category.

800 million dollars more annually on R&D than the newer firms. It's worth noting that according to the first regression, there is not significant change in expenditures in the recent 17 years and that the number of annual acquisitions is not significantly correlated with R&D expenditures.

More interesting are the results from the second regression, since in this case we account for size within the variables. According to the results, one unit increase in previous year's profit margin decreases current R&D margin (R&D/Sales) by 0.08 units. More intuitively, if profit margin in one year is low, firms tend to invest more in R&D the following year. This result might seem contradictory to the one obtained earlier, but what changes the matter must be the different approach to account for the size of the company.

The company "age" estimate (variable NEW) is consistent with the one obtained above, as for the trend variable, in this model it is statistically significant and negative. That means that during the last 17 years R&D margin has been reduced by 0.01 per year.

Conclusions

This research is an attempt to analyze the internal factors affecting firms' decisions about R&D expenditures. The obtained results do not meet all our expectations about the firm's behavior. As it turns out over time firms tend to invest less relative to their sales. However, the previous year's profit margin does have incentive power for following year's firm's decision. The ratio approach used in this research is something that was not used in previous studies. Using this ratio approach provides different intuitive results with respect to net income and R&D expenditures relationship.

Limitations

Because we use secondary data available through the Purdue University libraries and because of limited amount of time, our dataset has several limits. First, we would have liked to look at the effects of public research. Indeed, the government invests lots of money for public research. Finding out whether or not this money positively affects innovation, i.e., is effective, is of interest and would prove that the stagnation of funding for public R&D may be a significant problem (Schimmelpfennig, Pray and Brennan, 2003). We tried to follow Schimmelpfennig, Pray and Brennan (2003) by using the number of scientists at the USDA and land grant universities. According to them, this information is available in the USDA's Current Research Inventory System (CRIS). In our limited amount of time and knowledge of this inventory system, we were not able to find the information. Second, we would have liked to test the effect of patents on R&D. Patents of private firms would grasp the effectiveness of R&D and therefore affect how much the firm believes in R&D and will spend in it. If patents are an important way to stimulate innovation, government officials may want to spend more to help the creation and protection of property rights through patents. The information for patents can be available through the Derwent world patent index (Schimmelpfennig, Pray and Brennan, 2003). This dataset requires a membership and is not available through the Purdue University Libraries. Another dataset is the US Patent & Trademark Office (http://www.uspto.gov/patft/index.html). We investigated this dataset. However, it requires an impressive amount of time to compile the information into a dataset since it is not readily available by company's name and by year but only by patents number and inventor's name. Further research with more time could build the patent information into the dataset or use the patent information as dependent variable, for a proxy at innovation from an output standpoint.

This study does not take into account the industry and market specific factors, such as concentration, Herfindahl index, etc. That is, we assume they have no affect on firms' behavior, which is a very strong assumption. It should be taken into account that introduction of market and industry specific parameters may not only improve the explanatory power of the model, but might even have some impact on estimated parameters (even their signs). This leaves room for further research and development of this study.

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Appendix 1: Tables

Table 1. Companies with the SIC Code 2879 and 0721 in Mergent Database

SIC Code 2879	
Alcide Corp.	Ihara Chemical Industry Co., Ltd.*
American Vanguard Corp.*	Incitec Ltd.*
Ancom Berhad*	Jiangsu Yangnong Chemical Co., Ltd.*
Anhui Huaxing Chemical Industry Co., Ltd.*	Jiutian Chemical Group Ltd.*
Auriga Industries A/S	Ko Yo Ecological Agrotech Group Ltd.*
Benzenex S.A. Adubos e Inseticidas*	Kumiai Chemical Industry Co., Ltd.*
Bioprospect Ltd	Makhteshim Chemical Works Ltd.*
BioSyent Inc.*	Monsanto Co.
Bodisen Biotech Inc.**	Monsanto India Ltd.*
Chemco Holdings Ltd.*	Nanjing Redsun Co Ltd.*
Chongqing Min-feng Agrochem Co Ltd.*	Nantong Jiangshan Agrochemical & Chemicals Co. Ltd.*
Converted Organics Inc	Nihon Nohyaku Co., Ltd.*
Cyanamid Agro Ltd*	Nissan Chemical Industries, Ltd.*
Dawood Hercules Chemicals Ltd.*	Noble Group Ltd.*
Dongbu Hannong Chemical Company Ltd.*	Normiska Corp.*
Ecogen Inc.	Nortech Forest Technologies, Inc.
EcoScience Corp.	Omnia Holdings Limited*
eFoodSafety.com Inc	Pato Chemical Industry Public Co Ltd.*
Engro Chemical Pakistan Ltd.**	Pivot Ltd.*
Fertibras S.A. Adubos e Inseticidas*	PURE Bioscience
Fufeng Group Ltd.*	S.T. Corp*
Fujian Sannong Group Co Ltd.*	Scotts Miracle-Gro Co (The)*
Fumakilla Ltd*	Shandong Dacheng Pesticide Co Ltd.*
Greencore Group Plc	Shandong Huayang Technology Co., Ltd.*
Gujarat State Fertilizers & Chemicals Ltd.*	Terra Nitrogen Co., L.P.*
Hoechst Pakistan Ltd.*	TTI Industries, Inc
Hokko Chemical Industry Co., Ltd.*	UAP Holding Corp.*
Humatech, Inc.	Unida Co Ltd.*
Hunan Haili Chemical Industry Co Ltd.*	Verdant Brands, Inc.*
Igene Biotechnology, Inc.	Zhejiang Qianjiang Biochemical Co Ltd.*
SIC Code 0721	
Agrotech Greenhouses Inc.*	Rowe Evans Investments PLC**
Eden Bioscience Corp.	Syngenta AG
Kretam Holdings Berhad*	Tanah Emas Corp*
Makhteshim Agan Industries Ltd	United Malacca*
Mycogen Corp.	

* Companies that were not included because they do not report their expenses in Research and Development.
** Companies that were not included because Mergent does not report their financial statement.

Table 2. List of Companies Used in the Study

SIC code 2879	SIC code 0721	SIC Code 2870
Alcide Corp	Syngenta	Bayer AG
Auriga Industries A/S	Makhteshim Agan Industries Ltd	BASF AG
Ecogen Inc.	Mycogen Corp.	Du Pont (E.I.) de Nemours & Co
Monsanto		Dow Chemical Co
		Novartis AG Basel

Table 3. Descriptive Statistics of the Model Variables

		Mean	Std. Dev.
Number of Observations	90		
Number of Firms	17		
Sales (thsd $)		15402116	16172664
R&D (thsd $)		1015732	1257471
Net Income (thsd $)		1131460	2067933
Total Assets (thsd $)		20563129	20628859
Annual Number of Acquisitions		1.83	1.90
Firms Established after 1990 (%)	0.44		

Table 4. OLS Regression Results with Variables in Absolute Terms

Parameter	Estimate	Standard Error	t-value	p-value	
(Intercept)	-227500.000	310700.000	-0.732	0.467	
NIPREV	0.338	0.047	7.214	0.000	***
ACQ	66610.000	44500.000	1.497	0.139	
LARGE	963300.000	292500.000	3.293	0.002	***
NEW	-832500.000	211100.000	-3.943	0.000	***
TREND	25730.000	26590.000	0.967	0.337	

******* **α=0.01 or lower**
****** **α=0.05**
***** **α=0.1**

Table 5. OLS Regression Results with Variables in Relative Terms

Parameter	Estimate	Standard Error	t-value	p-value	
(Intercept)	0.225	0.033	6.794	0.000	***
PMPREV	-0.079	0.048	-1.670	0.100	*
ACQ	-0.003	0.004	-0.618	0.539	
NEW	-0.033	0.017	-1.991	0.051	*
TREND	-0.011	0.003	-3.749	0.000	***

******* **α=0.01 or lower**
****** **α=0.05**
***** **α=0.1**